OPERATING INSTRUCTIONS

TYPE 1390-B

RANDOM-NOISE GENERATOR

GENERAL RADIO COMPANY

759-H

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RANDOM-NOISE GENERATOR

Form 759-H
September, 1960

GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS, USA

SPECIFICATIONS

Frequency Range:	20 kc. Spectrum level is uniform from 20 cps to 20 kc within ±1 db. 500 kc. Spectrum level is uniform from 20 cps to 500 kc within ±3 db. 5 Mc. Spectrum level is uniform from 20 cps to 500 kc within ±3 db and from 500 kc to 5 Mc within about ±8 lb. Noise energy is also present beyond these limits. The level is down approximately 3 db at 5 cps.
Output Voltage:	Max open-circuit output is at least 3 volts for 20-kc range, 2 volts for 500-kc range, and 1 volt for 5-Mc range.
Typical Spectrum Level (with one volt output):	20-kc band. 5 mv for 1-cps band. 500-kc band. 1.2 mv for 1-cps band. 5-Mc band. 0.6 mv for 1-cps band.
Output Impedance:	Source impedance for max output is approx 900 ohms. Output is taken from a 2500-ohm potentiometer. Source impedance for attenuated output is 200 ohms. One output terminal is grounded.
Waveform:	Noise source is a gas tube that has good normal or Gaussian distribution of amplitudes for narrow ranges of the frequency spectrum. Over wide ranges the distribution becomes less symmetrical because of dissymmetry introduced by the gas tube. Appreciable clipping occurs on the 500-kc and 5-Mc ranges.
Voltmeter:	Rectifier-type average meter measures output. It is calibrated to read r-m-s value of noise.
Attenuator:	Multiplying factors of 1.0, 0.1, 0.01, 0.001, and 0.0001. Accurate to ±3% to 100 kc, within ±10% to 5 Mc.
Accessories Supplied:	Power cord, spare fuses, extensions for relay-rack mounting.
Mounting:	Metal cabinet.
Power Supply:	105 to 125 (or 210 to 250) volts, 50 to 60 cps.
Power Input:	About 50 watts.
Tubes Supplied:	6D4(1), 6AQ5 (2), 3-4 (1), 115NO30T (1).
Dimensions:	Width 12-3/4 in., height 7-1/2 in., depth 9-3/4 in. (325 by 195 by 250 mm). Panel height for 19-inch relay-rack mounting is 7 inches.(485 by 180 mm).
Weight:	12 lb (5.5 kg) (bench mounting).

General Radio Experimenter reference: Volume 34, No. 1, January, 1960

Special Request to the User of This Instrument

We believe that the most effective way to make our products more useful is to learn from the experience and opinions of those who use them. For this reason we have included a questionnaire at the rear of this manual. Your answers to the questions contained, based on your experience in using this instrument, will be of great value to General Radio engineers and other personnel concerned with new products. Such comments will have a strong influence on the direction of future development work. The resulting better products will benefit our customers as well as ourselves.

The questionnaire is its own postage-paid envelope. Simply fold as directed, staple, and mail.

Any information you supply will not go outside our Company without your specific authorization. Your reply will be acknowledged, and your questions answered by GR engineers concerned with this instrument. May we have your comments?

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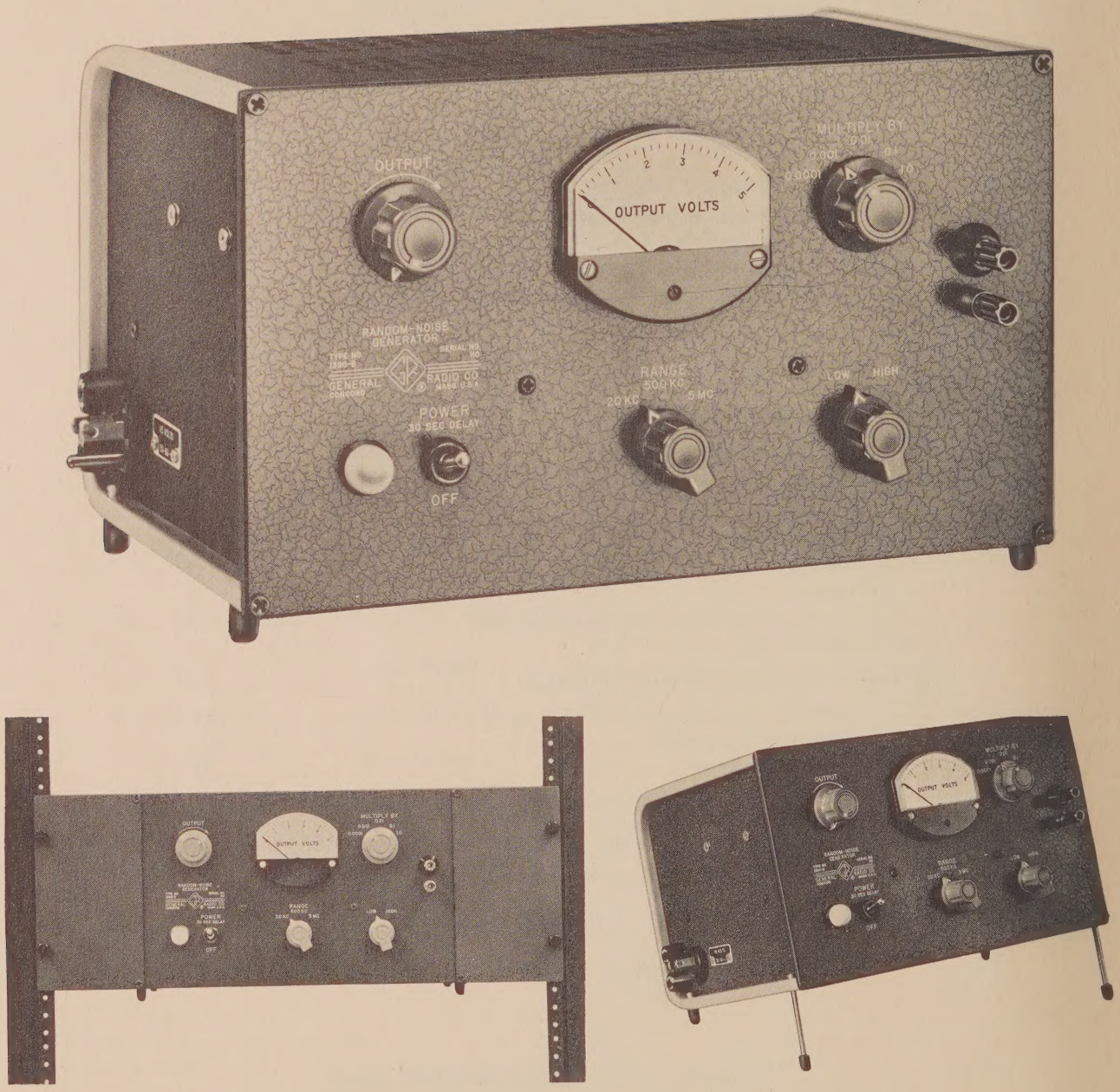

Figure 1. Type 1390-B Random-Noise Generator.

TYPE 1390-B
RANDOM-NOISE GENERATOR

Section 1
INTRODUCTION

1.1 PURPOSE. The Type 1390-B Random-Noise Generator (Fig. 1) provides a high level of electrical noise at its output terminals. This type of signal is useful in room acoustic measurements, loudspeaker and microphone tests, psychoacoustic tests, filter tests, crosstalk measurements for multichannel carrier systems, calibration checks on recording systems, modulating signal generators and test oscillators, tests of r-m-s response of meters, observation of resonance in systems, electrical averaging of resonant responses and comparisons of effective band width. A pair of these generators can be used as signal sources for demonstration of various degrees of correlation, possible errors of random sampling, and other concepts of statistical theory.

1.2 DESCRIPTION.

1.2.1 CONNECTIONS. Two jack-top binding posts, used as output terminals, are provided on the panel of the Type 1390-B Random-Noise Generator.

1.2.2 CONTROLS. The following controls are on the panel of the Type 1390-B Random-Noise Generator:

Name	Description	Positions	Use
RANGE	3-position rotary selector switch	20 kc, 500 kc, 5 Mc	Selects network used for shaping noise spectrum.
POWER	2-position toggle switch	OFF, POWER	Energizes instrument.
None	2-position rotary selector switch	LOW, HIGH	In LOW position, introduces a 10:1 resistance pad after gas-tube noise source to reduce effect of amplitude limitations of amplifier and to reduce noise field radiated by the instrument.
OUTPUT	Continuous rotary control		Varies output voltage.
OUTPUT VOLTS	Rectifier-type, average voltmeter		Indicates r-m-s value of noise at output terminals.
MULTIPLY BY	5-position rotary selector switch	0.0001, 0.001, 0.01, 0.1, 1.0	Attenuates output voltage.

Section 2

THEORY OF OPERATION

2.1 GENERAL. (See Figure 2.) The Type 1390-B Random-Noise Generator uses a gas-discharge tube as its noise source. A transverse magnetic field is applied to the tube to eliminate the oscillations usually associated with a gas discharge and to increase the noise level at high frequencies[1]. The noise output from the gas tube is amplified in a two-stage amplifier. Between the first and second stages the noise spectrum is shaped in one of three different ways, depending on the setting of the RANGE switch. At the 20-kc position, a low-pass filter is inserted, which has a gradual roll-off above 30 kc, with the audio range to 20 kc uniform in spectrum level. At the 500-kc setting, a low-pass filter is inserted, which rolls off above 500 kc. At the 5-Mc setting, a peaking network is used. This network approximately compensates for the drop in noise output from the gas tube at high frequencies, so that a reasonably good spectrum is obtainable out to 5 Mc.

2.2 OUTPUT VOLTAGE. The maximum open-circuit output voltage on the 20-kc band is at least 3 volts, on the 500-kc band at least 2 volts, and on the 5-Mc band at least 1 volt. This corresponds to a relatively high noise level, since the output impedance at maximum output is only about 900 ohms. This level can be expressed in terms of the resistance noise corresponding to 900 ohms at room temperature. The r-m-s voltage in a one-cycle band due to thermal agitation in a 900-ohm resistor at room temperature is about 3.8×10^{-9} volts. The level from the Type 1390-B Random-Noise Generator is about five millivolts for a one-cycle band when there is a total output voltage of one volt on the 20-kc band. This level, then, is about 1,300,000 times the corresponding voltage for resistance noise, or about 122 decibels above resistance noise at the same impedance level.

2.3 CHARACTERISTICS OF NOISE OUTPUT. As shown in Figure 3, no regular pattern appears in the output waveform; it is characterized by randomness rather than regularity. Noise is therefore described by statistical means,[2] and is characterized by its distribution of instantaneous amplitudes and by its frequency spectrum.

A random noise is often defined as a noise that has a "normal" or "Gaussian" distribution of amplitudes. This concept is illustrated by the following simple experiment performed with the noise generator.

Set the noise generator to the 20-kc band and to maximum output. Connect a small capacitor (about 1000$\mu\mu$f) across the output. Suddenly disconnect the capacitor. Measure its voltage with an electrometer or

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[1] J. D. Cobine and J. R. Curry, "Electrical Noise Generators", Proc. IRE, Vol. 35, No. 9, September 1947, pp. 875-879.

[2] S. O. Rice, "Mathematical Analysis of Random Noise", Bell System Technical Journal, Vol. 23, No. 3, July 1944, pp. 282-332; Vol. 24, No. 1, January 1945, pp. 46-156.

A. van der Ziel, Noise, New York, Prentice-Hall, Inc., 1954.

W. B. Davenport, Jr. and W. L. Root, An Introduction to the Theory of Random Signals and Noise, New York, McGraw-Hill, 1958.

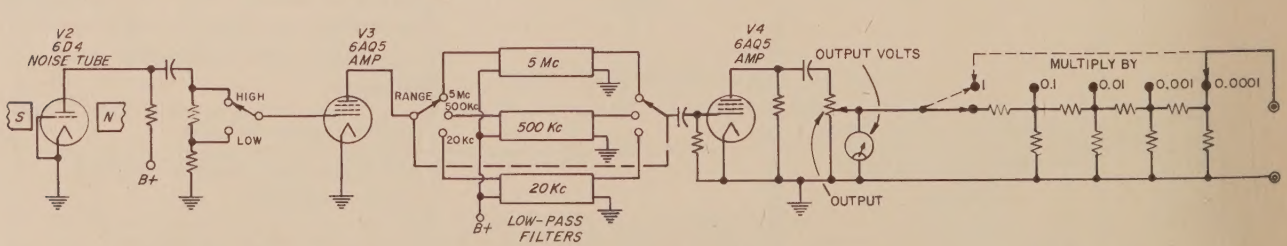

Figure 2. Elementary Circuit Diagram.

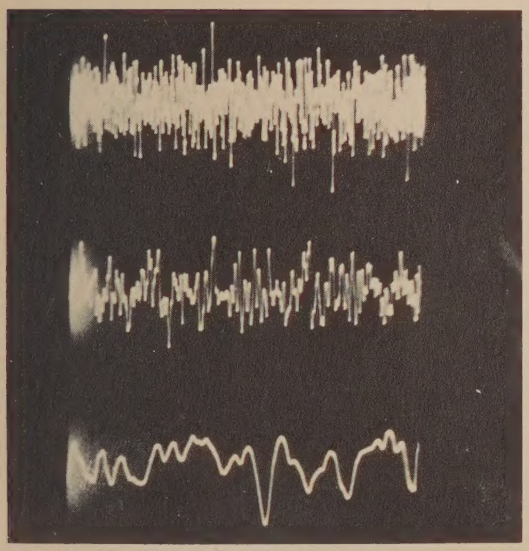

Figure 3. Oscillograms of Three Different Samples of the Output Voltage Wave. (A single sweep was used for each. Middle trace is at four times, and lower trace 20 times sweep speed of upper trace.)

its charge with a ballistic galvanometer. Record this value, which is the instantaneous amplitude of the noise voltage at the time the capacitor is disconnected. A series of these values can be obtained, and a graph prepared, with instantaneous amplitude versus the percentage of time during which any amplitude is exceeded. A large number of amplitudes must be determined in this way before a reliable distribution results. Two or three hundred observations are usually sufficient to show the trend for demonstration purposes, while several thousand will give a reliable curve for the important part of the range. Because of the large number of observations required, automatic apparatus is helpful in making these determinations.[3]

Figure 4 illustrates a chart made up after 400 observations. This chart shows the fraction of observations in each interval of 0.2 volt. It is seen that most of the observations were relatively low values, although some relatively high values were observed. These results are also shown in a qualitative way in the oscillograms in Figure 3.

[3] McKnudtzon, "Experimental Study of Statistical Characteristics of Filtered Random Noise", Technical Report No. 115, M.I.T. Research Laboratory of Electronics, July 15, 1949.

L. W. Orr, "Wide-Band Amplitude Distribution Analysis of Voltage Sources", Review of Scientific Instruments, Vol. 25, No. 9, Sept., 1954, pp. 894-898.

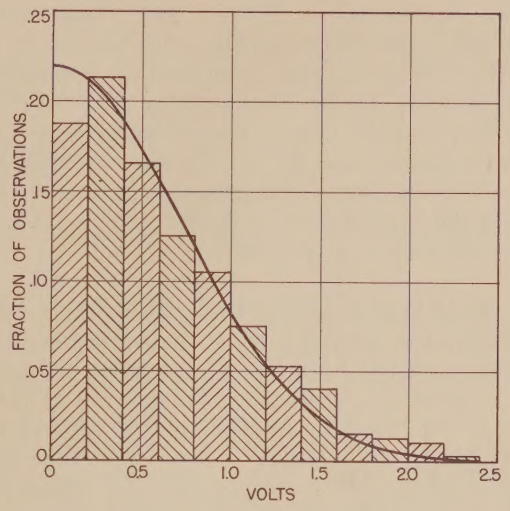

Figure 4. Results of Voltage-Sampling Experiment. (Continuous curve is a normal probability distribution curve adjusted according to r-m-s value of noise voltage and size of intervals used in plot.)

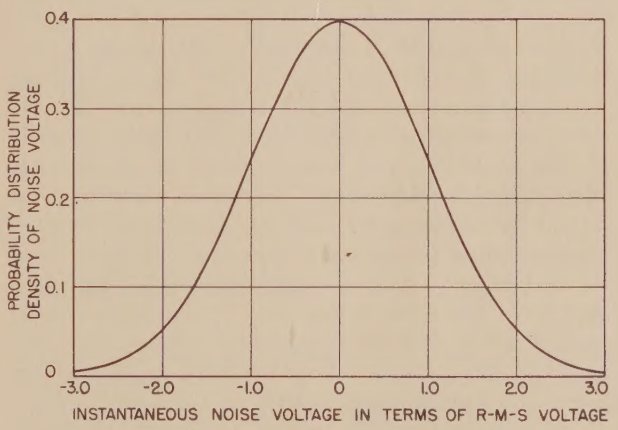

Figure 5.
Normal Distribution Curve of True Random Noise.

The normal (Gaussian or Laplacian) distribution curve is also shown in Figure 4. It has been adjusted according to the computed r-m-s value of the data (the standard deviation) and the size of the interval used in plotting the data. The experimental data fit the normal curve very closely. Departures from the normal curve are almost entirely the result of so few observations. Had more observations been made, the result would have been even closer to the expected values.[3]

In Figure 5, the probability that a voltage between two limits will be observed is given by the area under the normal curve between those two limits. Ex-

pressed in other terms, if the output voltage is observed over long periods of time, the fraction of the total time that the voltage is between the two voltage limits is given by the corresponding area under the probability curve.[4] For example, the instantaneous voltage magnitude will be no more than one-tenth the r-m-s value for about eight percent of the time, and will be greater than three times the r-m-s value only about 0.26 percent of the time.

2.4 DEPARTURES OF OUTPUT FROM TRUE RANDOMNESS. The curve in Figure 5 is symmetrical about the origin, and the noise of the generator is reasonably symmetrical, though some dissymmetry is introduced by the gas tube. In addition, the inherent amplitude limitations of the vacuum-tube amplifiers limit the distribution curve at high levels. The normal distribution is modified only slightly on the 20-kc range, while clipping occurs on the other ranges.

2.5 FREQUENCY SPECTRUM OF NOISE. The meaning of the term "frequency spectrum of noise" is illustrated in the following experiment. If a wave analyzer, such as the Type 736-A Wave Analyzer, is used to analyze the output of the noise generator, a fluctuating meter reading will be observed at any setting of the analyzer. If an average value of this reading is taken over a period of time very long compared with 0.25 second (corresponding to four-cycle effective band width of the analyzer), this average value is the level in that four-cycle-wide band. This level, determined on any of the ranges of the noise generator, is essentially independent of the frequency setting of the Type 736-A Wave Analyzer. Thus the spectrum in this region is uniform. The relative spectrum of the noise can be determined by the use of suitable analyzers to cover the full range of the principal energy regions of the noise. A typical result of such an analysis is shown in Figure 6 for the three bands of the Type 1390-B Random-Noise Generator. When the spectrum is uniform over a broad band, as shown in Figure 6, it is commonly called "white noise". The "whiteness" always applies to a definite band only. For example, if the noise spectrum is uniform from 100 to 500 kc, the noise is referred to as white in that band.

It is customary to adjust the measured value of analyzed noise to that corresponding to an ideal filter of one-cycle band width. Since noise voltage increases as the square root of the band width, the value determined on the Type 736-A Wave Analyzer is then

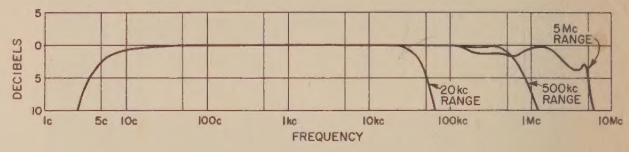

Figure 6. Typical Spectrum Level Characteristics for Type 1390-B Random-Noise Generator.

divided by $\sqrt{\frac{4 \text{ cycles}}{1 \text{ cycle}}}$ to obtain what is called "spectral voltage density". This can be defined as the r-m-s voltage corresponding to the energy contained within a band one cycle per second wide.

NOTE

"Spectral voltage density", although a convenient term, is sometimes not used because most work on noise deals with energy level. The transfer from one to the other requires a knowledge of the impedance level in the circuit. It should be remembered that separate noise signals add on an energy basis and that the noise energy increases directly with the noise bandwidth, while the noise voltage increases as the square root of the bandwidth. Furthermore, the concept used here assumes a uniform density of the noise signal over the band of the analyzer. It should not be used for discrete components.

2.6 ANALYSIS OF NOISE BY CONSTANT-PERCENTAGE ANALYZERS. If the output of the Type 1390-B Random-Noise Generator is analyzed by a Type 760-B Sound Analyzer, the results will be similar to those shown in Figure 7. Here the indicated level increases 10 decibels for each decade increase in frequency. This result can be understood by realizing that this analyzer has a band width that is essentially a constant percentage of the center frequency. For example, at 5 kc the effective band width for noise is about 160 cps, and at 500 cps is about 16 cps.

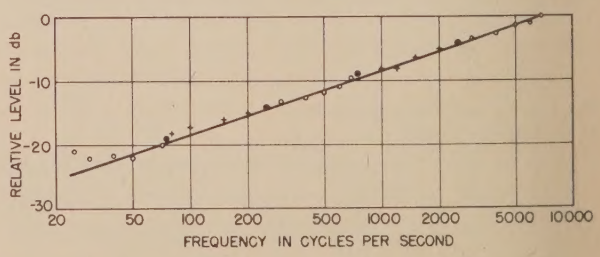

Figure 7. Results of Analysis of Noise-Generator Output Voltage by a Type 760-B Sound Analyzer. (Straight line drawn at slope of 10 db per frequency decade.)

[4] E. R. Neinburg and T. F. Rogers, "Amplitude Distribution Analyzer", Radio-Electronic Engineering, Vol. 46, No. 6, December 1951, pp. 8-10.

Section 3
INSTALLATION

3.1 BENCH MOUNTING. To set the instrument in a tilted position (shown in inset of Figure 1), simply pull each front leg down as far as possible and then turn the leg so that its notch faces the back of the instrument.

To restore the leg to its retracted position, turn it to release the catch and push the leg up.

3.2 RELAY-RACK MOUNTING. To mount the Type 1390-BR Random-Noise Generator in a relay rack, first attach the two adaptor plates to the instrument. Remove the two screws in the upper and lower corners on one side of the panel. These screws fasten the panel to the aluminum end frames. Place one of the adaptor plates in the front of the panel so that the corner holes on the plate line up with those on the instrument and replace the two screws.

Attach the second adaptor plate on the other side of the instrument panel in the same manner. The instrument can then be mounted in a standard 19-inch relay rack.

3.3 POWER SUPPLY CONNECTION. Connect the Type 1390-B Random-Noise Generator to the power line by means of the cord-and-plug assembly provided.

CAUTION

Be sure that the line voltage and frequency agree with those specified on the metal plate at the power input socket. Instruments are normally equipped for 115-volt operation. Power-transformer connections can be changed, as indicated on the wiring diagram, to convert the instrument for 230-volt operation. When connections are changed, the metal plate should be reversed to read correct voltage.

Section 4
OPERATING PROCEDURE

4.1 START-UP. Turn the POWER switch on. After 30 seconds, when the heater of the Type 6D4 thyratron tube has warmed up, plate voltage is applied by an internal time-delay relay. (Simultaneous application of heater and plate voltage would shorten the useful life of the thyratron tube and increase the drift in noise-output level on warm-up.)

4.2 FREQUENCY CONTROL. The RANGE switch selects the network used for shaping the noise spectrum. Markings indicate the upper frequency limits for which the noise spectrum is reasonably uniform.

4.3 OUTPUT CONTROL. Output controls are a switch for selecting LOW or HIGH output, an OUTPUT level control, and an output attenuator. In the LOW position, the switch introduces a 10:1 resistance pad after the gas-tube noise source. This reduces the effect of the unavoidable amplitude limitations of the vacuum-tube amplifier and also reduces the noise field radiated externally by the instrument. To keep hum and microphonics to a minimum, however, it is generally advisable to operate the instrument in the HIGH position.

The OUTPUT level control is a continuous-type control that is used to vary the output voltage from a very low value to maximum for either setting of the output switch.

The MULTIPLY BY switch is used to provide low output levels. It has multiplying factors of 0.1, 0.01, 0.001, and 0.0001.

4.4 VOLTMETER. A rectifier-type, average meter measures the output voltage. It is calibrated to indicate the rms value of the noise. When the MULTIPLY BY switch is at 1.0, the meter indicates directly the open-circuit voltage at the output terminals. In the other positions of the MULTIPLY BY switch, the open-

circuit output voltage is the product of the meter reading and the multiplier reading.

The spectral voltage density of the noise at a given frequency is the r-m-s voltage corresponding to the energy contained within a band 1-cps wide centered on that frequency. The typical spectral voltage density at 1 kc with one volt output is approximately as follows:

(a) 20-kc band: 5 millivolts for one-cycle band.
(b) 500-kc band: 1.2 millivolts for one-cycle band.
(c) 5-Mc band: 0.6 millivolt for one-cycle band.

When an accurate value is desired at any frequency, it should be measured. The values given are intended only as a guide.

4.5 LOAD. The output is taken from a 2500-ohm potentiometer, and one output terminal is grounded. For a truly resistive load with the MULTIPLY BY switch at 1.0, the apparent source impedance is zero when a reading of the voltmeter is taken with the load connected, since the voltmeter reads the voltage across the load. As the output control is varied from the maximum to the minimum setting, the actual source impedance varies from about 900 ohms to nearly zero. When the MULTIPLY BY switch is in any position other than 1.0, the source impedance is 200 ohms.

A load that is not independent of frequency will affect the frequency spectrum of the output noise. For example, a capacitor shunted across the output terminals will decrease the level of the high-frequency noise more than it decreases the level of the noise at low frequencies. The voltmeter is then less indicative of the spectrum level than it is for a resistive load.

4.6 HUM. The hum level is usually more than 40 db below the over-all noise level in the HIGH output position. This hum level is sufficiently low so that for most applications there is no effect from hum, even when an analyzer with a narrow band is used for analysis. The relative hum level in the HIGH output position is lower than that in the LOW position.

4.7 APPLICATIONS.

4.7.1 GENERAL. Some applications of a noise generator depend on its amplitude distribution characteristics (Figures 4 and 5.) For example, the amplitude distribution is similar to that of speech, music, and many other sounds or electrical disturbances that occur naturally[5], while the amplitude distribution of a sine

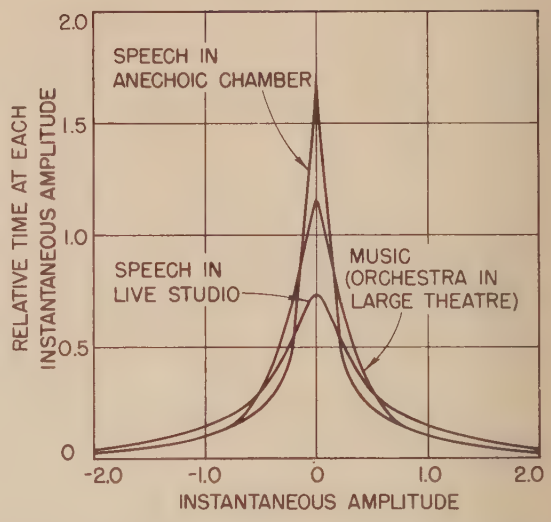

Figure 8a. Amplitude Distribution Curves for Various Sounds. (Curves labeled "Speech" are for particular cases of sounds produced from readings of printed matter[5]; curve labeled "Music" is an analysis of an orchestral selection made in a large theater[5].

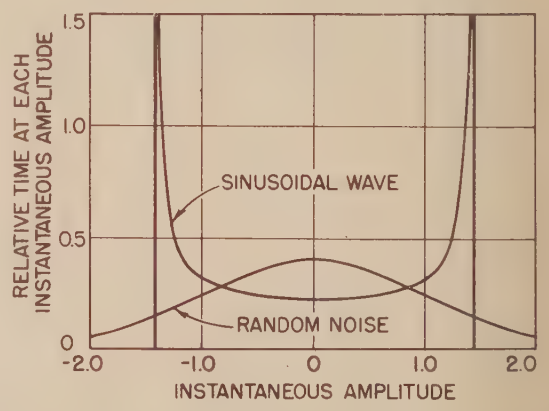

Figure 8b. Distribution Curves of a Single Sinusoidal Wave and a Random Noise.

wave is entirely different. These similarities and differences can be seen by comparison of the distributions of Figure 8. Because of this characteristic, random noise is an important signal for psychoacoustic tests. Psychoacoustic tests include masking or interference tests, loudness measurements, determination of critical bandwidths, and audiometric tests. The techniques used in making such tests are discussed in the various numbers of the Journal of the Acoustical Society

[5] H. K. Dunn and S. D. White, "Statistical Measurements on Conversational Speech", Journal of the Acoustical Society of America, Vol. 11, No. 3, January 1940, pp. 278-288.

W. B. Davenport, Jr. "A Study of Speech Probability Distributions", M.I.T. Laboratory of Electronics, Technical Report No. 148, August 25, 1950.

of America (for which there are two comprehensive indexes available) and in various psychological journals. A useful bibliography for these applications is S. S. Stevens, J. G. S. Loring, and Dorothy Cohen, Bibliography on Hearing, Harvard University Press, Cambridge, 1955, particularly those references listed in Sections 139 (p. 571), 157 (p. 573) and 222-228 (pp. 579 f).

Other applications depend on the various possible frequency spectra of noise. The frequency spectrum is independent of the amplitude distribution, in the sense that a normal distribution of amplitudes is possible with any frequency spectrum - flat, broad, narrow, sloping, or peaked. Systems that affect one characteristic, however, may also affect the other. For example, nonlinear clipping affects both the amplitude distribution and the frequency spectrum. Linear filter networks used on purely random noise do not affect the randomness but alter the frequency characteristic and correspondingly the time scale. Linear filter networks used after clipped noise alter the frequency spectrum and also tend to make the noise more nearly random.

4.7.2 ELECTROACOUSTIC TESTS. The Type 1390-B Random-Noise Generator is a useful signal source for many types of electroacoustic tests, including loudspeaker-response tests. Some useful discussions of these tests using a noise source are given in the following: Leo. L. Beranek, Acoustic Measurements, New York, John Wiley and Sons, 1949, pp. 639-640, 665 f, 697-702; and RMA Standard SE-103, Speakers for Sound Equipment, April 1949, p. 6, Standard Test Signal BA.

Other General Radio instruments useful in electroacoustic tests are the Type 1551-B Sound-Level Meter, the Type 1551-P1 Condenser Microphone System, the Type 1550-A Octave-Band Analyzer, the Type 1554-A Sound and Vibration Analyzer, and the Type 1521-A Graphic Level Recorder.

4.7.3 ROOM ACOUSTICS TESTS. The noise generator is a useful signal source for many types of tests in room acoustics. These include reverberation tests, panel (wall and floor) transmission measurements, measurement of space irregularities, and measurement of steady-state signal transmission. For details, consult the following: Leo. L. Beranek, Acoustic Measurements, New York, John Wiley and Sons, 1949, pp. 804 ff, 826 f, 831 and 883.

The Type 1551-B Sound-Level Meter, the Type 1550-A Octave-Band Analyzer, the Type 1554-A Sound and Vibration Analyzer, and the Type 1521-A Graphic Level Recorder are useful elements in the over-all set-up for these tests.

4.7.4 STATISTICAL DEMONSTRATIONS. The properties of noise that concern the amplitude-time relationship are usually described by statistical means[2]. (Refer to paragraph 2.3.)

Random-noise generators can be used to demonstrate some concepts of statistical theory. The equipment and methods for demonstrating various degrees of correlation and possible errors of random sampling are described by J. C. R. Licklider and E. Dzendolet, "Oscillographic Scatterplots Illustrating Various Degrees of Correlation", Science, January 30, 1948, Vol. 107, No. 2770, pp. 121-124.

4.7.5 NOISE AT HIGH FREQUENCIES. The noise generator can be used to modulate an r-f carrier when a noise signal is desired at a frequency above 5Mc. The Type 1000-P6 Crystal Diode Modulator[6] is a suitable instrument for wide-band modulation, and the Type 1208-B V-H-F Unit Oscillator[7] and Type 1209-B U-H-F Unit Oscillators[7] are suitable r-f oscillators covering the range from 65 to 920 Mc.

Because of the two sidebands that result from the standard modulation techniques, the noise band can be made to extend over a 10-Mc range, 5 Mc on each side of the carrier. For some applications it may be desirable to use a suppressed-carrier or balanced-type modulator (see Terman, Radio Engineering Handbook, New York, McGraw-Hill Book Co., 1943, pp. 551-553). It is also possible to use a series of carriers and modulators to combine to give a much broader band of noise than 10 Mc.

Some signal generators and oscillators include modulating circuits, so that an external source such as the Type 1390-B Random-Noise Generator can be used to modulate the signal. Instruments of this type are the Types 1001-A, 1021-AU, and 1021-AV Standard Signal Generators. For these generators the modulation produced is limited to the audio range and to about 5 to 10 percent rms noise modulation, with peaks much higher. When a wider frequency band is desired, the Type 1000-P6 or some other external modulator should be used as described above.

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[6] Byers, W. F., "An Amplitude Modulator for Video Frequencies", General Radio Experimenter, March 1950, Vol. 24, No. 10, pp. 6-8.

[7] E. Karplus, "V-H-F and U-H-F Unit Oscillators", General Radio Experimenter, May 1950, Vol. 24, No. 12, pp. 7-11.

4.7.6 VERY HIGH NOISE LEVELS. When noise levels even higher than those provided by the Type 1390-B Random-Noise Generator are desired, an amplifier should be used, such as the Type 1206-B Unit Amplifier. The Type 1233-A Power Amplifier is useful when a wide frequency range is desired.

4.7.7 INTERFERENCE TESTS. Since noise is a common form of interfering or disturbing signal or signal that limits the threshold of detectability, the noise generator can be used to check receivers, communication systems, and detection systems for susceptibility to interference. It can also be used as a training aid for operators who must communicate through interference.

4.7.8 OVER-ALL CALIBRATION TESTS. The noise generator can be used as an over-all calibration device because of the wide frequency range available at the output. This calibration signal can be particularly useful in audio systems that involve a recording technique, and its use can frequently simplify the calibration procedure when an analyzer forms part of the system.[8]

For example, when a magnetic tape recorder is used to record a signal to be measured on playback, reference signals must be recorded before and after the unknown signal is recorded. These reference signals permit one to fix levels and to determine response characteristics, which can vary from time to time depending on the condition of the tape and the machine. These reference signals are usually a series of tones at various points in the frequency range of interest. The noise generator, due to the broad frequency band, permits the use of a more versatile reference signal. Thus a useful set of reference signals would be a burst of noise of about one-half minute duration and a burst of a 400-cycle tone of about the same length. These two signals would permit the determination of frequency response, signal-to-noise ratio, harmonic distortion (at one level and one frequency), and flutter.

To determine the frequency response by use of a noise signal, perform the following operations:

1. Set the noise generator to the 20-kc range. Connect it to the input of the system under test, at such a level that the r-m-s input is at least 14 decibels below the sine-wave overload point.

2. Make a frequency spectrum analysis of the input noise signal and of the output noise signal from the device under test. The relative level of input and output as a function of frequency is then the frequency response of the device under test, unless spurious signals are present in the output of the device.

3. Test for spurious signals by making an analysis of the output with no input signal applied.

When these measurements are made, the input and output must be analyzed by analyzers of the same effective bandwidth. The bandwidth of the analyzer should also be appreciably smaller than the bandwidth of the device under test. Furthermore, the ultimate attenuation of the analyzer should be much greater than variation in response that one expects to measure, so that it will not limit the observed response. Distortion and background noise in the device under test will also limit the range of variation in response that can be measured by this method, and it is therefore important to select the proper level for input signal.

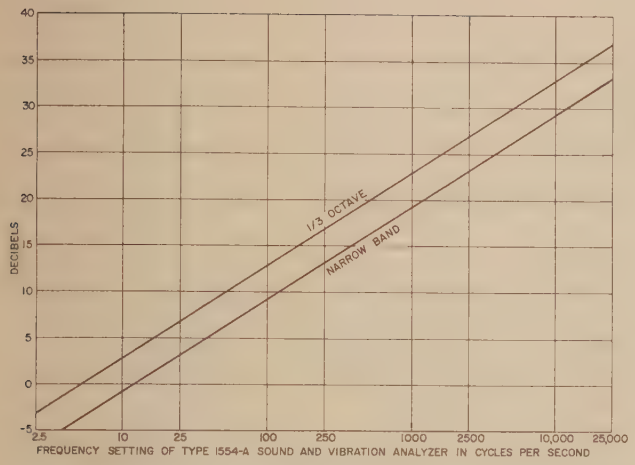
4.7.9 ANALYSIS OF NOISE. In the course of measurements with a noise generator, it is often necessary to make a frequency spectrum analysis of noise. The Type 760-B Sound Analyzer, the Type 736-A Wave Analyzer, the Type 1550-A Octave-Band Noise Analyzer, and the Type 1554-A Sound and Vibration Analyzer are useful accessories for this analysis in the audio-frequency range. The results of noise analyses by these three different analyzers cannot be compared directly; the results must be modified because of the different bandwidths. Refer to paragraph 2.5 for a discussion of the frequency spectrum of noise.

The bandwidth of the Type 1550-A Octave-Band Noise Analyzer increases in cycles directly with the mean frequency of the band. For that reason, a noise signal that is uniform in spectral-energy density over the frequency range will give higher-level readings for the higher-frequency bands than for the lower-frequency bands. The following table shows the values to be subtracted from the readings of the analyzer to obtain the spectral-density levels.

Band	Decibels to be subtracted from the octave-band levels to obtain spectral-density levels.
20-75	18
75-150	19
150-300	22
300-600	25
600-1200	28
1200-2400	31
2400-4800	34
4800-10 Kc	38

The effective bandwidth of the Type 760-B Sound Analyzer or of the Type 1554-A Sound and Vibration

[8] S. S. Stevens, J. P. Egan, and G. A. Miller, "Methods of Measuring Speech Spectra", Journal of the Acoustical Society of America, Vol. 19, No. 5, September 1947, pp. 771-780.



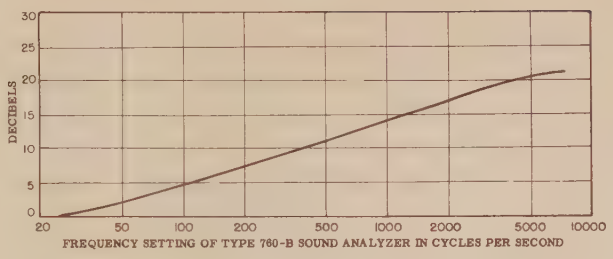


Figure 9. Plots Showing Number of Decibels to be Subtracted from Analyzer Reading to Obtain Spectral Density Level.

Analyzer increases with increase in the frequency to which the analyzer is tuned. The graphs in Figure 9 show the value in decibels that must be subtracted from the reading of the analyzer to obtain the spectral-density level. This value is determined on the basis of initial calibration of the instrument by a sine-wave signal.

4.7.10 FREQUENCY RESPONSE MEASUREMENT. The noise generator can be used in place of the usual sine-wave oscillator for measuring the response of circuits and systems. In this application the selective characteristics of generator and detector are reversed from those ordinarily used in point-by-point measurements; the wide-band noise source and a selective detector replace the single-frequency source and wide-band detector. For speech and music circuits, this technique provides a much closer approximation to operating conditions than does the older system. This approach is particularly useful in testing recording systems.[8] The usual sweeping sinusoidal tests are sometimes inconvenient because of the problem of determining the recorded frequency during playback. This problem is eliminated by a recorded noise signal that is analyzed on playback.

Because of its broad frequency spectrum, noise is often used to avoid the marked resonance effects that can occur when vibrations in mechanical structures and acoustical systems are measured. The use of noise as a source in measuring the reverberation characteristics of rooms and the transmission characteristics of building structures results in a type of electrical averaging of the characteristics, provided a reasonably broad band is used. This averaging often simplifies the comparison of the characteristics of different structures.

The noise generator is useful in response measurements on loudspeaker systems in rooms.[9] The electrically averaged response can be used to determine the optimum characteristic for equalizing networks, to set the relative levels of woofer and tweeter units, and to adjust levels of multiple-speaker units installed in different locations in a large hall.

4.7.11 RESONANCE TESTS. Because of its broad frequency spectrum, noise can sometimes simplify the search for resonant conditions in a system.[10] The resonance produces a peak in the frequency spectrum, which can be observed in oscillographic displays.

4.7.12 OTHER USES. The noise generator can also be used in crosstalk measurements[11], for masking crosstalk in multichannel communication systems[12], and to drive vibrators in component testing[13], or for noise factor comparison tests[14].

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[9] L. L. Beranek, Acoustic Measurements, New York, John Wiley, 1949, pp. 665-668 and 697-702.

[10] Emory Cook, "White-Noise Testing Methods", Audio Engineering, Vol. 34, No. 3, March 1950, pp. 13-15.

[11] J. P. Vasseur, "Les foisceaux hertziers a courants porteurs devant les recommandations du C.C.I.F.", Annales de Radioelectricite, Vol. 9, No. 35, January 1954, pp. 47-82.

[12] A. J. Aikens and C. S. Thaeler, "Noise and Crosstalk on N1 Carrier Systems", Electrical Engineering, Vol. 72, No. 12, December 1953, pp. 1075-1080.

[13] J. Robbins, "Standardized White Noise Tests", Electronic Industries & Tele-Tech, Vol 16, No. 2, February, 1957, pp. 68-69.

S. H. Crandall, ed., Random Vibration, Cambridge, Massachusetts, The Technology Press of MIT, 1958.

[14] IRE "Standards on Electron Devices: Methods of Measuring Noise", Proceedings of the IRE, Vol. 41, No. 7, July 1953, pp. 891-896.

Section 5

SERVICE AND MAINTENANCE

5.1 GENERAL. The two-year warranty given with every General Radio instrument attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible.

In case of difficulties that cannot be eliminated by the use of these service instructions, please write or phone our Service Department, giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest district office (see back cover), requesting a Returned Material Tag. Use of this tag will insure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

5.2 ACCESS TO COMPONENTS. To remove the shield, loosen the two fluted locking screws on the back of the instrument. These will unlock on the first turn, but should be loosened the maximum amount before the shield is removed. Pull the shield straight back from the panel.

5.3 PRELIMINARY CHECKS. If the noise generator is inoperative, make the following checks before removing the case. Make sure that the a-c supply is plugged into a live power line, that the power switch is turned to the POWER position, that the output control is turned up, that the time-delay relay is operative, and that the fuses are not open.

5.4 METER DOES NOT READ. Disconnect any load from the output terminals to insure that the load impedance is not too low to permit a meter reading. Place the output switch in the HIGH position.

5.5 TUBE REPLACEMENT. Since the vacuum tubes have a shorter life on the average than the other components used in the instrument, they should be tested if the instrument is still inoperative after the above checks have been made.

The Type 6D4 Gas Triode used as the noise source is aged and selected for uniformity of the noise spectrum and for good amplitude characteristics. If the tube has deteriorated and must be replaced, some selection among different tubes of this type may be necessary to find a satisfactory replacement.

5.6 HEATER VOLTAGE OF TYPE 6D4 GAS TUBE. The potentiometer at the rear of the chassis is for setting the heater voltage of the gas tube. Over certain ranges of heater voltage, some gas tubes will "sputter". The meter indication on the 20-kc range will often reveal this sputter. Under normal conditions, the meter reading fluctuates two or three precent. When sputtering occurs, the meter reading may fluctuate 10 percent or more. The sputtering is more easily detected by observation of the noise pattern on an oscillograph or by ear with a good pair of earphones. The heater voltage should be set so that this sputtering does not occur. Some selection among tubes of this type may be necessary to find a tube that is free from sputtering.

5.7 VOLTAGE MEASUREMENTS. The following tables give test voltages for aid in troubleshooting:

T1 TRANSFORMER MEASUREMENTS

Between Terminals	AC Volts
10 and 11	120
5 and 6	17
6 and 7	17
8 and 9	6.3

TABLE OF VOLTAGES

TUBE	PIN	VOLTS
V1 (3-4)	2	13.4
	7	6.3
V2 (6D4)	3	6.3
	4	0
	7	15.0
V3 (6AQ5)	1	0
	2	6
	3	20
	4	13.4
	5	230 (A) 220 (B) 100 (C)
V3 (6AQ5) (Cont.)	6	125 (A) 125 (B) 115 (C)
V4 (6AQ5)	1	0
	2	12
	3 to 4	6.3 ac
	5	165
	6	235
V5 (115NO30T)	4	120 ac*
	9	120 ac*

NOTES

Voltages are measured with VTVM and are dc with respect to ground unless otherwise stated.

(A) S3 = 5 Mc
(B) S3 = 500 kc
(C) S3 = 20 kc

*Voltages are measured with a 1000Ω /volt rectifier meter, and are with respect to terminal 11 on transformer T1.

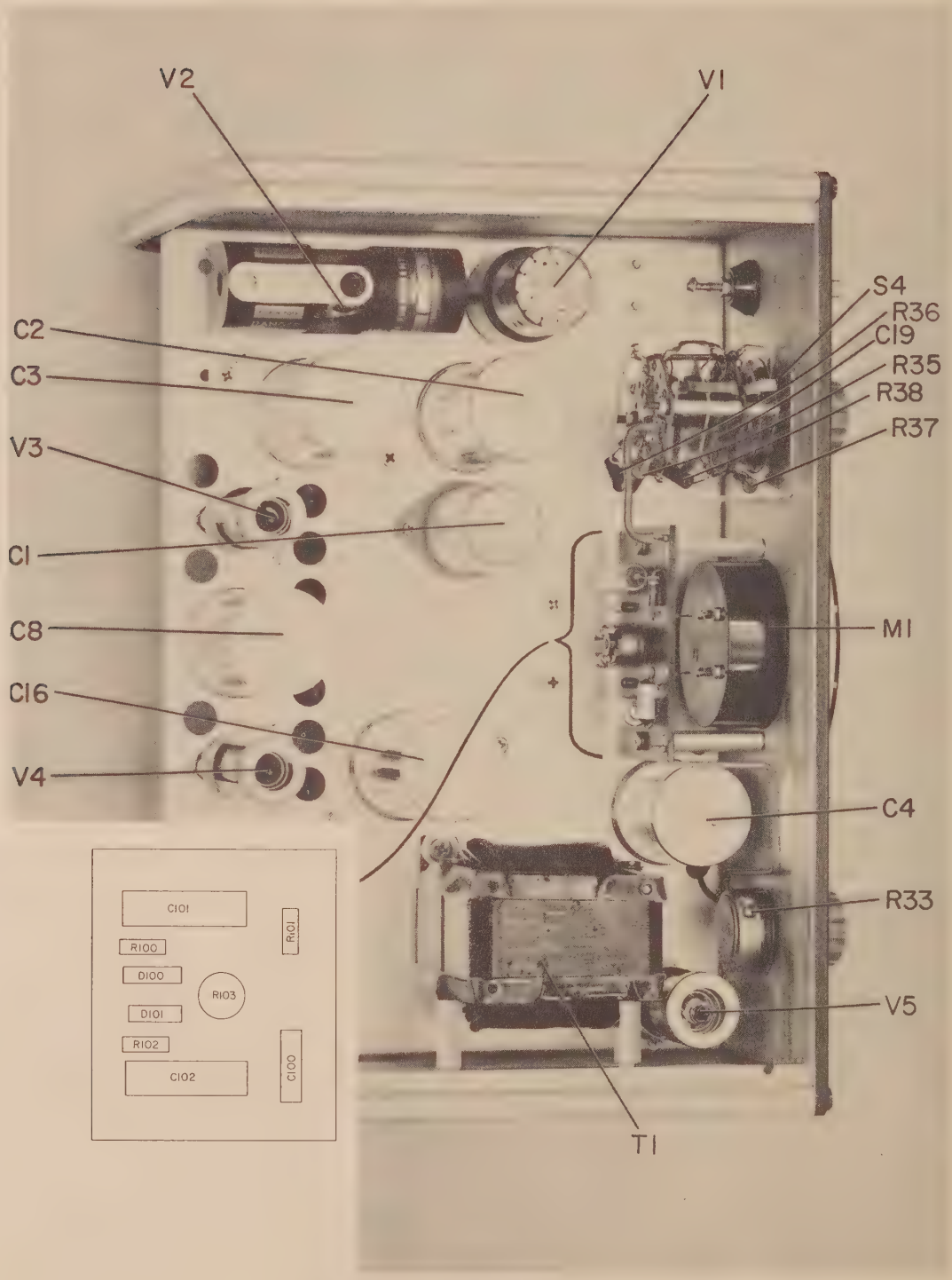

Figure 10. Top Interior View.

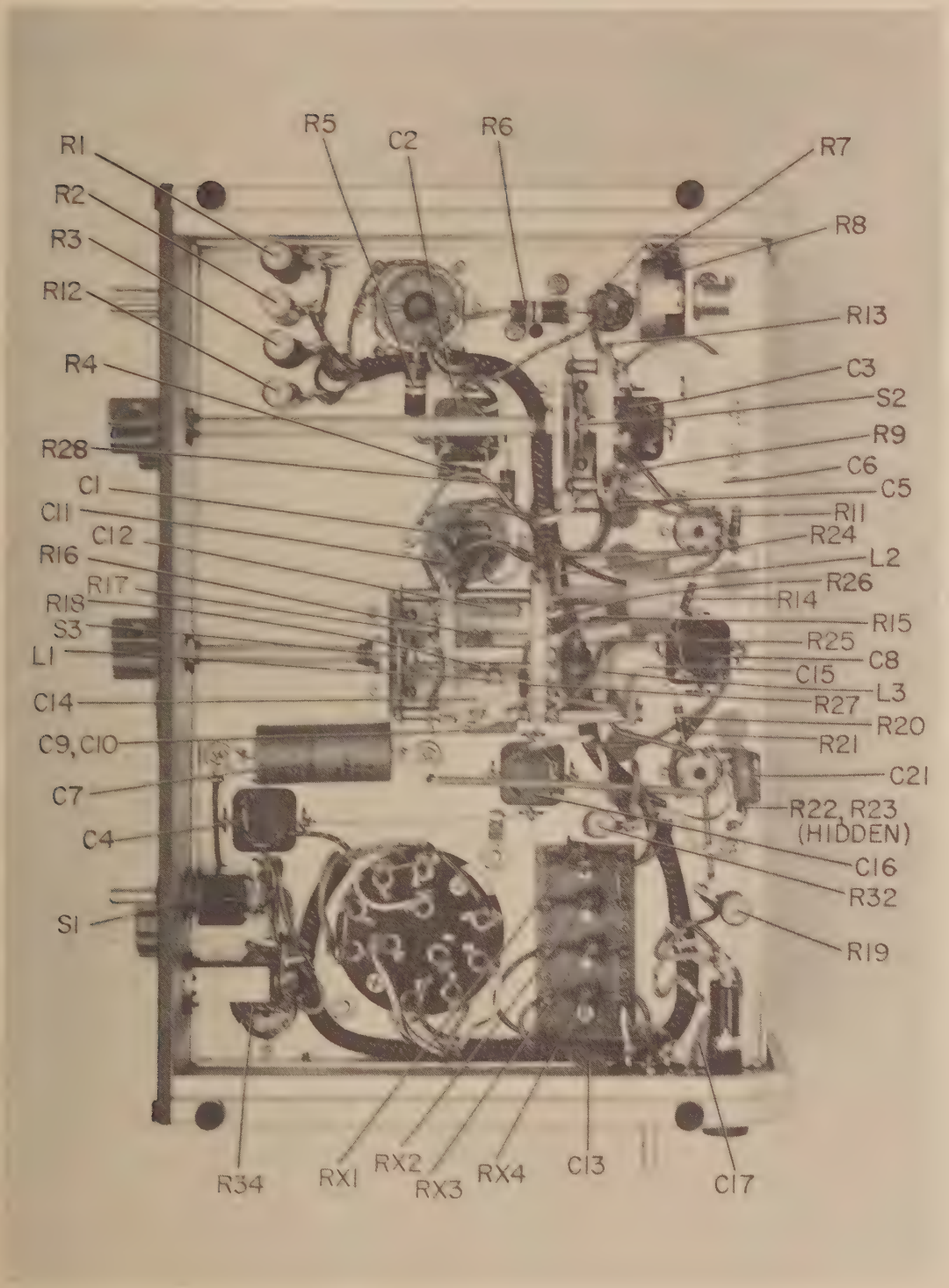

Figure 11. Bottom Interior View.

PARTS LIST

PART NO. (NOTE A)				
RESISTORS (NOTE B)				
R1	470	±10%	5 w	REPO-22
R2	330	±10%	5 w	REPO-22
R3	220	±10%	5 w	REPO-22
R4	5.1 k	±10%	1 w	REC-30BF
R5	10 k	±10%	2 w	REC-41BF
R6	10 k	±10%	2 w	REC-41BF
R7	56	± 5%	1/2 w	REC-20BF
R8	250	±10%		POSW-3
R9	150 k	± 5%	1/2 w	REC-20BF
R10	16 k	± 5%	1/2 w	REC-20BF
R11	330	± 5%	1/2 w	REC-20BF
R12	100	±10%	5 w	REPO-22
R13	2.2 k	± 5%	1/2 w	REC-20BF
R14	56	± 5%	1/2 w	REC-20BF
R15	56 k	± 5%	1/2 w	REC-20BF
R16	330	± 5%	1/2 w	REC-20BF
R17	68	± 5%	1/2 w	REC-20BF
R18	22 k	± 5%	1/2 w	REC-20BF
R19	2.2 k	±10%	5 w	REPO-22
R20	470 k	± 5%	1/2 w	REC-20BF
R21	56	± 5%	1/2 w	REC-20BF
R22	180	± 5%	1/2 w	REC-20BF
R23	150	± 5%	1/2 w	REC-20BF
R24	9.1 k	± 5%	5 w	REPO-43
R25	820	±10%	1 w	REC-30BF
R26	3.9 k	± 5%	1/2 w	REC-20BF
R27	220	± 5%	1/2 w	REC-20BF
R28	5.1 k	±10%	1 w	REC-30BF
R32	1.5	±10%	5 w	REPO-22
R33	2.5 k	±10%		POSC-7
R35	2 k	± 1%	1/4 w	REF-65
R36	2 k	± 1%	1/4 w	REF-65
R37	2 k	± 1%	1/4 w	REF-65
R38	2 k	± 1%	1/4 w	REF-65
R39	246.9	±0.25%		700-352
R40	246.9	±0.25%		700-352
R41	246.9	±0.25%		700-352
R42	222.2	±0.25%		700-351
R100	2.7 k	± 5%	1/2 w	REC-20BF
R101	4.3 k	± 5%	1/2 w	REC-20BF
R102	5.1 k	± 5%	1/2 w	REC-20BF
R103	5 k	±20%		POSC-22

CAPACITORS (NOTE C)				
C1A	25		200 dcwv	COE-51
C1B	25			
C2A	50		450 dcwv	COE-10
C2B	25			
C2C	25			
C3A	50		450 dcwv	COE-10
C3B	25			
C3C	25			
C4A	500		25 dcwv	COE-39
C4B	250			
C4C	250			
C5	1.0 μμf	±10%		COC-1
C6	0.47	±10%	600 dcwv	COP-19
C7	15		300 dcwv	COE-27
C8A	50		450 dcwv	COE-10
C8B	25			
C8C	25			
C9	680 μμf	±10%		COM-20B
C10	470 μμf	±10%		COM-20B
C11	0.0022	±10%		COL-71
C12	300 μμf	±10%		COM-20B
C13	0.01	+100% -0		COC-63
C14	5-20 μμf	±10%		COT-18
C15	0.33	±10%	600 dcwv	COP-19
C16A	1500		10 dcwv	COE-9
C16B	750			
C16C	750			
C17	0.01	+100% -0		COC-63
C18	50 μμf	±10%		COC-21
C19	50 μμf	±10%		COC-21
C20	50 μμf	±10%		COC-21
C21	470 μμf	±10%		COM-20B
C100	10 μμf	±10%		COM-5B
C101	100		3 dcwv	COE-46
C102	100		3 dcwv	COE-46

DIODES			
D100	1N34-A	D101	1N34-A

FUSES		
F1	(for 115 v) 0.6 amp Slo-Blo 3AG	FUF-1
F1	(for 230 v) 0.3 amp Slo-Blo 3AG	FUF-1

Continued

PARTS LIST (Continued)

FUSES (Continued)			RECTIFIERS			
F2	(for 115 v) 0.6 amp Slo-Blo 3AG	FUF-1	RX1	1N1695	RX3	1N1692
F2	(for 230 v) 0.3 amp Slo-Blo 3AG	FUF-1	RX2	1N1695	RX4	1N1692
INDUCTORS			**SWITCHES**			
L1	22 μh ±10%	CHM-2	S1	SWT-33NP	S3	SWRW-181
L2	50 mh	379-35	S2	SWRW-180	S4	SWRW-182
L3	0.5 mh	CHA-579A	**TRANSFORMER**			
METER			T1	485-497		
M1	0-200 μa 680 Ω	MEDS-92	**TUBES**			
PILOT LAMP			V1	3-4	V4	6AQ5
P1	Mazda Type 44	2LAP-939	V2	6D4	V5	115N030T
			V3	6AQ5		

NOTES:

(A) Type designations for resistors and capacitors are as follows:

COC - Capacitor, ceramic	POSC - Potentiometer, composition
COE - Capacitor, electrolytic	POSW - Potentiometer, wire-wound
COL - Capacitor, oil-impregnated	REC - Resistor, composition
COM - Capacitor, mica	REF - Resistor, film
COP - Capacitor, plastic	REPO - Resistor, power
COT - Capacitor, trimmer	

(B) All resistances are in ohms unless otherwise designated by k (kilohms).

(C) All capacitances are in microfarads unless otherwise designated by μμf (micromicrofarads).

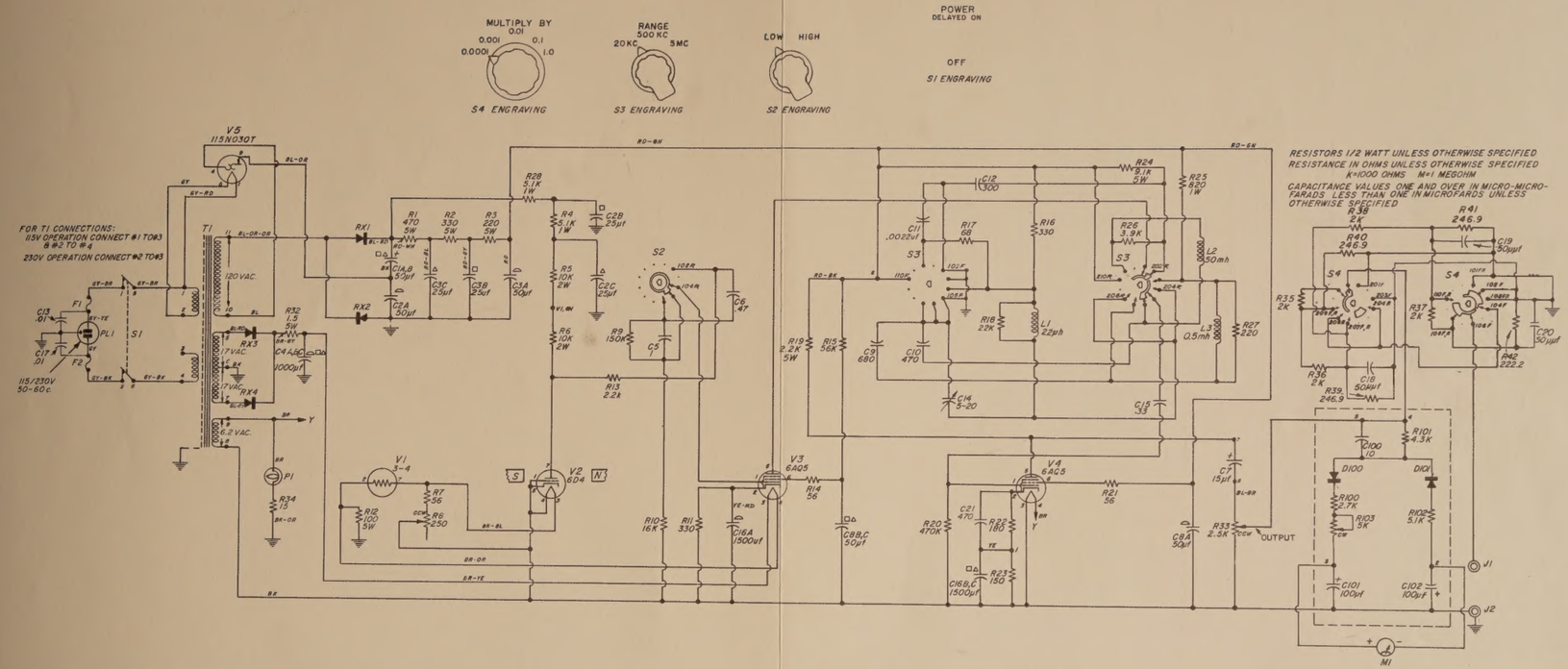

Figure 12. Schematic Wiring Diagram.

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